

TC 0076-06

# **FINAL REPORT REMEDIAL INVESTIGATION**

## **FORMER ASPHALT PLANT**

### **CAMP NAVAJO BELLEMONT, ARIZONA**

July 1999

*Prepared for:*

**US Army Corps of Engineers**  
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and

**Arizona Army National Guard**  
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**REMEDIAL INVESTIGATION  
AT  
CAMP NAVAJO**

**FORMER ASPHALT PLANT**

**DRAFT FINAL REPORT**

**Contract DACA05-93-D-0019**

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## LIST OF ACRONYMS

Acronym	Full Phrase
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ADEQ	Arizona Department of Environmental Quality
ADHS	Arizona Department of Health Services
AST	above ground storage tank
AZNG	Arizona National Guard
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
COC	chemical of concern
HA	hand auger
HBGL	health based guidance levels
LCS	laboratory control sample
LDC	Laboratory Data Consultants
MK	Morrison Knudsen Corp.
MS	matrix spike
PAH	polycyclic aromatic hydrocarbon
pcf	pounds per cubic foot
ppb	parts per billion
ppm	parts per million
PRG	preliminary remediation goal
RI	remedial investigation
RPD	relative percent difference
SS	surface soil
SSL	soil screening level
SVOC	semivolatile organic compound
TEPH	total extractable petroleum hydrocarbons
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TPH-d	total petroleum hydrocarbons as diesel
TRPH	total recoverable petroleum hydrocarbons
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound

# SECTION 1

## INTRODUCTION

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### 1.1. PURPOSE OF REPORT

This report summarizes the results of the remedial investigation conducted on the former asphalt plant (NAAD 29, NADA 29, AREE 29) (FAP, site) at Camp Navajo (formerly Navajo Depot Activity), in Bellemont, Arizona (Figure 1-1). Tetra Tech was retained by the United States Army Corps of Engineers (USACE) to conduct the work described in this report.

### 1.2. SITE BACKGROUND

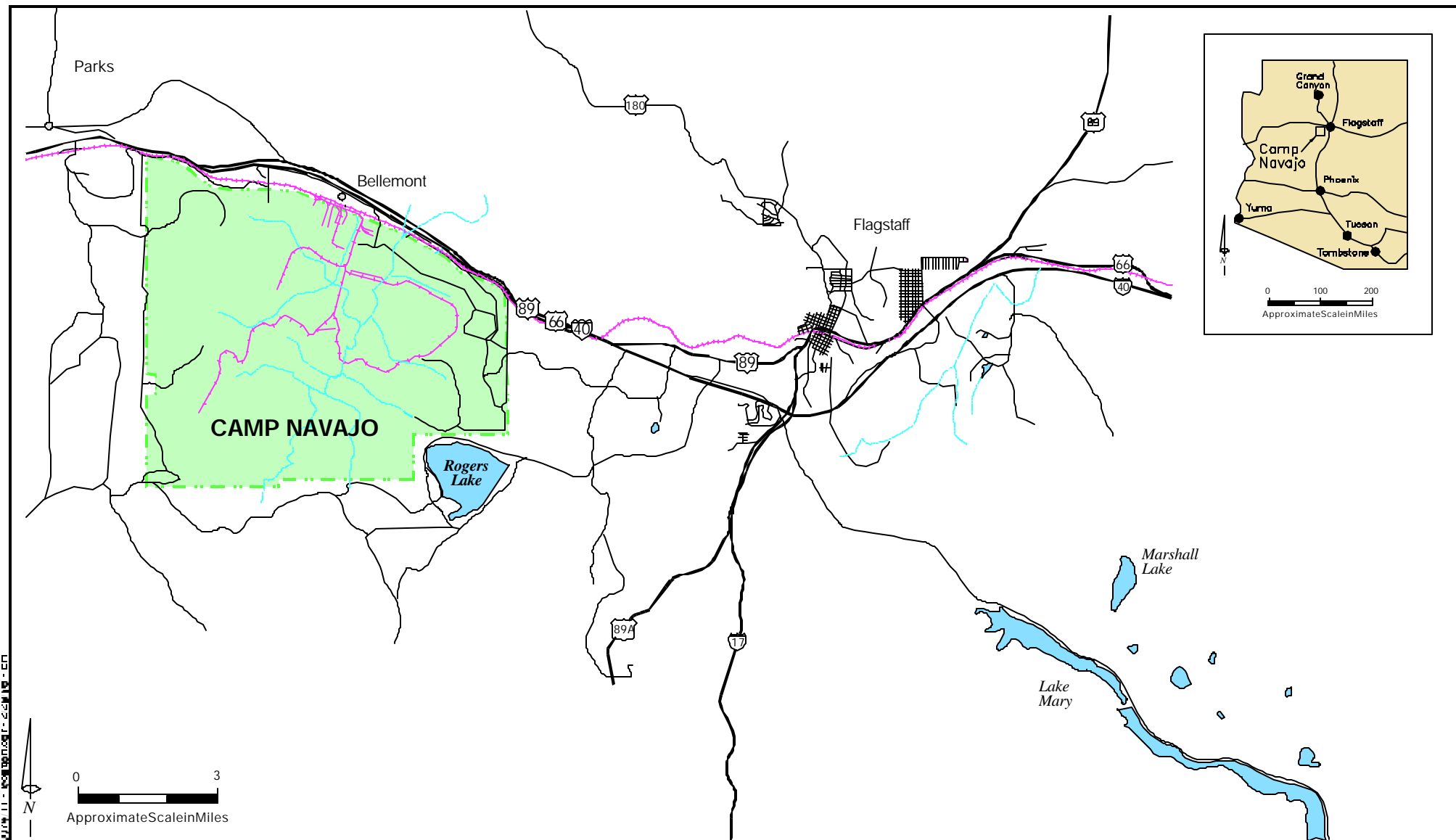
#### 1.2.1. Site Description

Building S-207, commonly referred to as the former asphalt plant, was 697 square feet in area (Figure 1-2) and was located in the southeastern portion of the warehouse area (Figure 1-3). The plant was built in 1942 at the same time Camp Navajo roads were being surfaced. The plant had a coal-fired heater to make hot oil for asphalt production. The asphalt emulsion was supplied from three elevated tanks and was reported to have been mixed with the aggregate on the ground. The plant was idle for many years with little or no maintenance, and the building was demolished in 1994.

Spread throughout the area are residues of asphalt and coal, and there appears to be limited vegetation growth in some places. Asbestos insulation at the plant has weathered and has scattered over the area (Uribe 1993). The asbestos has been removed from the boiler and the outside of the three aboveground storage tanks (ASTs). Coal is still present in wooden hoppers southwest of the boiler house (Uribe 1993).





#### 1.2.2. Previous Investigations

Tetra Tech found no information regarding previous investigations of the former asphalt plant.



Camp Navajo is in north central Arizona about 12 miles west of the city of Flagstaff.

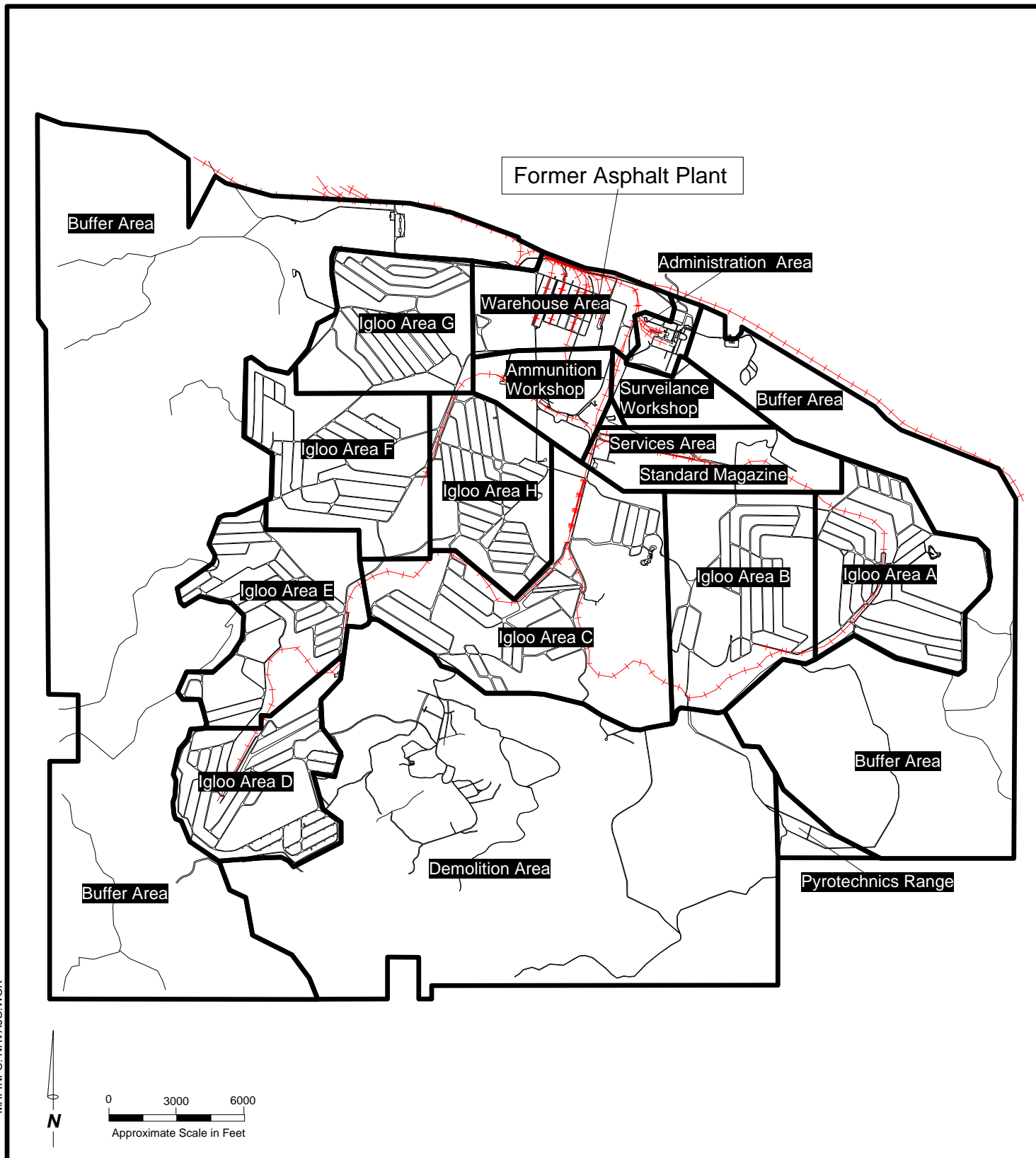
#### LEGEND:

-  Highways
-  Roads
-  Railroad
-  Rivers/Streams

## Camp Navajo Location Map

Camp Navajo  
Bellemont, Arizona

Figure 1-1

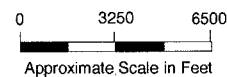
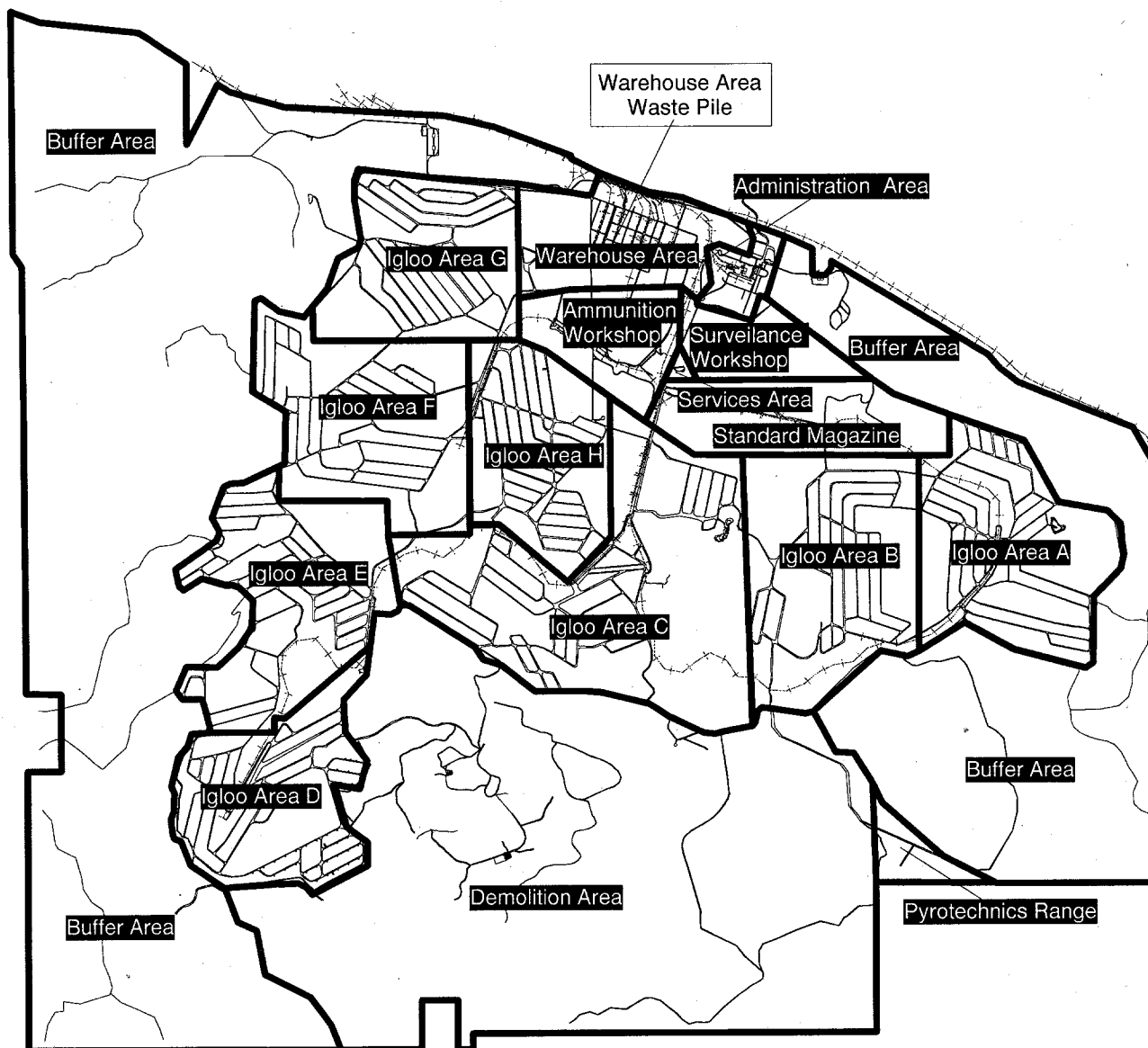


## ***Former Asphalt Plant Site Plan***

Camp Navajo, Bellemont, Arizona

**Figure 1-2**





***Warehouse Area Waste Pile***

***Site Map***

Camp Navajo, Bellemont, Arizona

**Figure 1-3**

**1.3. STATEMENT OF THE PROBLEM**

Previous operations at this site are likely to have generated petroleum hydrocarbon wastes. In addition, because operations at this site involved the handling of a liquid waste product (petroleum hydrocarbons), it is likely that spills occurred periodically.

**1.4. REPORT ORGANIZATION**

This report follows United States Environmental Protection Agency (USEPA) guidance for remedial investigation (RI) reports in the Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA 1988). Section 2 describes the field investigations conducted as part of the RI. Sections 3 and 4 present the physical and chemical results, respectively. Section 5 presents a discussion of the fate and transport characteristics of the contaminants. Section 6 presents risk screening for the identified contaminants. All results are summarized with conclusions in Section 7.

## SECTION 2

# SAMPLING PROGRAM

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### 2.1. SAMPLING OBJECTIVES

The specific objective of the investigation of the former asphalt plant is to determine the nature and extent of possible surface and subsurface contamination.

### 2.2. SAMPLING APPROACH

Photo documentation is provided in Appendix A. Field notes are presented in Appendix B. Field investigations were conducted in accordance with the procedures outlined in the field sampling plan provided in Appendix C. Geophysical survey results can be found in Appendix D. Surveyor results can be found in Appendix E.

#### ***Task 1: Geophysics***

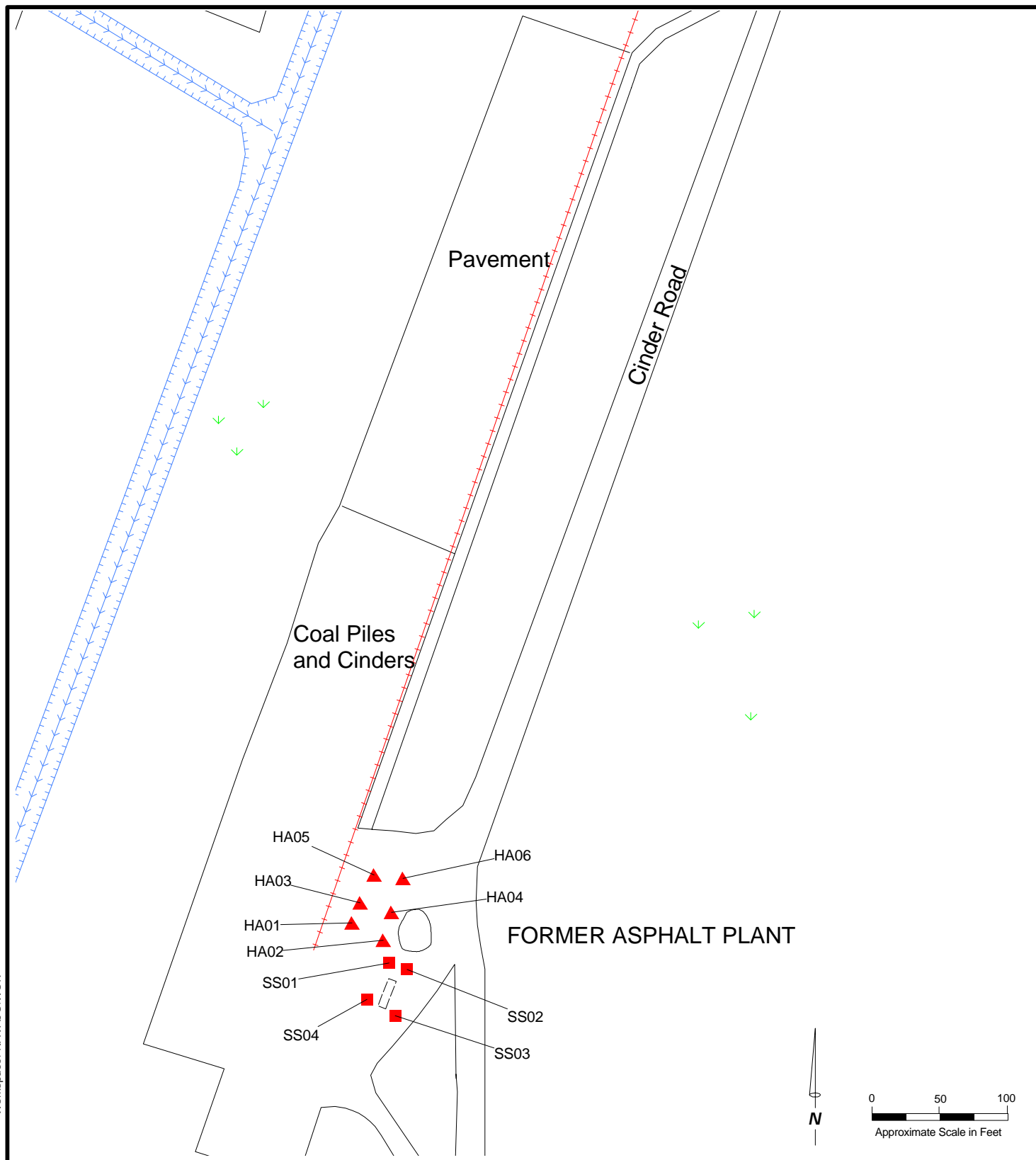
A line locating survey was conducted within a 20-foot zone surrounding the building and in any areas where subsurface sampling was performed.

#### ***Task 2: Surface Soil Sampling***

Surface soil sampling was performed in targeted locations deemed likely to represent worst case conditions based on engineering judgment. Four surface soil samples were taken at the locations shown in [Figure 2-1](#). Samples were collected by driving a 2-inch by 12-inch California modified split spoon sampler, as described in Appendix C. As shown in [Table 2-1](#), the laboratory analytical program for surface soil samples included petroleum hydrocarbons, semivolatile organic compounds (SVOCs), percent water, and pH. One sample also was analyzed for total organic carbon (TOC), redox potential, bulk density, and grain size.

#### ***Task 3: Hand Augering and Sampling***

Six hand auger locations were sampled beneath the storage tanks as shown in [Figure 2-1](#). Hand auger sampling was done to a maximum depth of five feet bgs.



**Legend:**

- Ditch
- Hand Auger Location
- Grass
- Railroad
- Slope
- Surface Soil Sample/Sediment Sample



**Tetra Tech, Inc.**

**Former Asphalt Plant**

**Investigation Plan**

Camp Navajo, Bellemont, Arizona

**Figure 2-1**

**Table 2-1**  
**Former Asphalt Plant Sample Analyses**

Sample ID	Sample Date	Depth (feet)	Media	Percent Water ASTM D2216	pH SW9045B	Total Organic Carbon W/BLACK	Redox Potential ASTM D1498	Dry Density ASTM D2937	Particle-Size Distribution ASTM D422	Petroclum Hydrocarbons BLS-191	Petroclum Hydrocarbons BLS-418 1 AZ	Semivolatile Organic Compounds SW8270B
FAP-SS01S-01	10/08/1995	1	Soil	X	X					X		X
FAP-SS02S-01	10/08/1995	1	Soil	X	X					X		X
FAP-SS03S-01	10/08/1995	1	Soil	X	X	X	X	X	X	X		X
FAP-SS04S-01	10/08/1995	1	Soil	X	X					X		X
FAP-SS05S-01*	10/08/1995	1	Soil	X	X					X		X
FAP-HA01S-01	10/12/1995	0.5	Soil	X	X	X	X			X	X	X
FAP-HA01S-02	10/12/1995	2.5	Soil	X	X					X	X	X
FAP-HA02S-01	10/12/1995	0.5	Soil	X	X					X	X	X
FAP-HA02S-02	10/12/1995	2.5	Soil	X	X					X	X	X
FAP-HA03S-01	10/12/1995	0.5	Soil	X	X					X	X	X
FAP-HA04S-01	10/12/1995	0.5	Soil	X	X					X	X	X
FAP-HA05S-01	10/12/1995	0.5	Soil	X	X					X	X	X
FAP-HA05S-02	10/12/1995	2.5	Soil	X	X					X	X	X
FAP-HA05S-03	10/12/1995	5	Soil	X	X					X	X	X
FAP-HA06S-01	10/12/1995	0.5	Soil	X	X					X	X	X
FAP-HA06S-02	10/12/1995	2.5	Soil	X	X					X	X	X
FAP-HA07S-01*	10/12/1995	0.5	Soil	X	X					X	X	X

Notes:

\* Blind duplicate sample (see section 4.3)  
ASTM American Society for Testing and Materials

Samples were collected by driving a 2-inch by 12-inch California modified split spoon sampler, as described in Appendix C. Soil samples were analyzed for petroleum hydrocarbons, SVOCs, percent water, and pH, as shown in Table 2-1. One sample also was analyzed for TOC and redox potential.

***Task 4: Surveying***

After the investigation was completed, Aztech Surveying, an Arizona-licensed land surveyor, surveyed the horizontal location of the samples. Horizontal coordinates for each location were surveyed relative to a permanent control point established on-site. Horizontal control is accurate to  $\pm 0.1$  feet. Sample locations in Figure 2-1 are based on survey results. A table of surveyed sample locations is included in Appendix E.

**2.3. SAMPLE ANALYSIS**

Seventeen soil samples were collected and analyzed during this investigation. Soil sample analyses conducted as part of this investigation included SVOCs, petroleum hydrocarbons, TOC, redox potential, percent moisture, and pH by Quanterra Laboratories in California. One soil sample also was analyzed for bulk density and particle-size distribution by Earth Tech Laboratories in California. Table 2-1 summarizes the samples collected and the types of analyses conducted on each soil sample.

## SECTION 3

# PHYSICAL CHARACTERISTICS

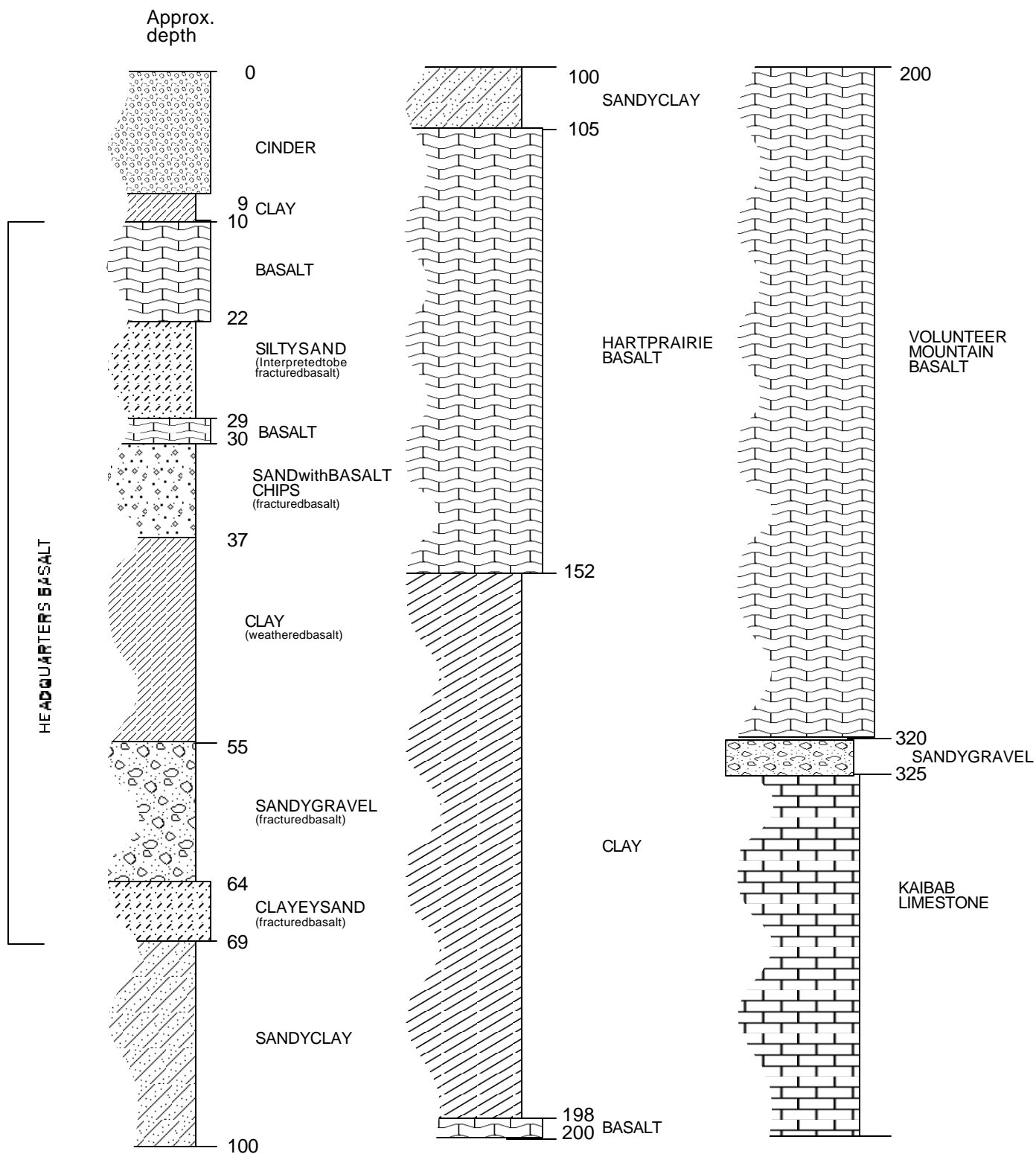
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### 3.1. SURFACE FEATURES

Surface features at the site consist of grasses and cinders. The topography in the area is generally of low relief, and slopes to the south. There is a northeast-southwest trending escarpment approximately 3,000 feet east of the site (Bellemont Fault). This feature has an increase in ground surface elevation of about 80 feet. Ground surface generally consists of gravel with less than 50 percent of sand.

### 3.2. GEOLOGY

The following description of the geology of the warehouse area is compiled from surface geologic mapping, and from soil borings in the Warehouse Area, and from geophysical surveys (Figure 3-1) (Tetra Tech 1999a). A monitoring well drilled in 1996 approximately 500 feet east of the site encountered a thin veneer (<10 feet) of clayey soil overlying a thickness of basalt. This basalt is interpreted to be the Headquarters Basalt which underlies the entire Warehouse Area as well as the adjacent Administration Area. The flow is estimated to be about 60 feet thick and overlies a thickness (<35 feet) of Camp Navajo Clay. The Camp Navajo Clay was deposited directly on top of a second basalt flow. This second basalt flow is interpreted to be the Hart Pairie basalt and is 45 feet thick. Below the second basalt is a second clay (45 feet thick) and a third basalt. The third basalt is interpreted to be the Volunteer Mountain basalt and is 120 feet thick. Below the third basalt is a thin zone of gravel and weathered Kaibab Formation (<20 feet) and the underlying Kaibab Formation.

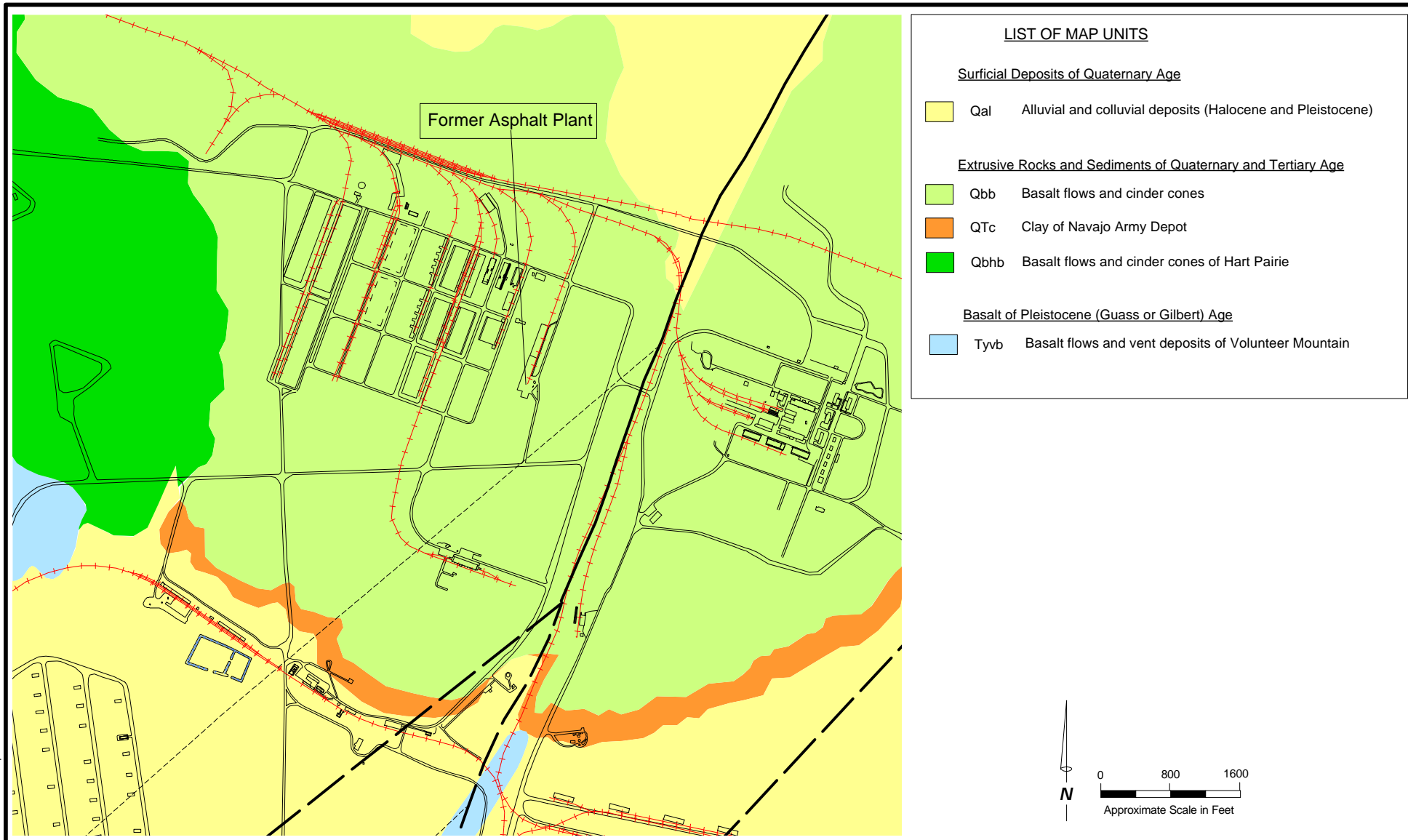


Source: TetraTech, 1996

### ***Former Asphalt Plant Stratigraphy***

CampNavajo  
Bellemont, Arizona





### 3.3. SOILS

The soils beneath the site have been classified by the Navajo Army Depot Soil Survey, Coconino County, Arizona, as Soil Unit 10 (USDA 1970). These are moderately deep gravelly clay soils with a loam surface and usually have zero to five percent slopes. The surface soil is generally a brown granular loam, having a pH of 7.0 and a thickness of three to five inches. The subsoil is generally a dark reddish gray gravelly clay with a blocky structure, having a pH of 7.8 and a thickness of 20 to 30 inches. This type of soil comprises approximately five percent of Navajo Army Depot soils, which accounts for approximately 1,400 acres of land on the base.

Physical testing of the soil samples collected during this investigation showed moisture at 12.4 percent. Dry densities of the soils range was 77.6 pounds per cubic foot (pcf). Grain size distributions was 22 percent gravel, 53 percent sand, 25 percent fines. All physical analysis results are included in Appendix G.

### 3.4. HYDROGEOLOGY

Four water bearing zones have been identified within the upper 2000 feet beneath the warehouse area. The uppermost zone, which feeds the springs from which the base receives its water supply, exists in fractures in the bottom of the uppermost basalt flow. The bottom of this zone is marked by a 30 foot thick clay aquitard at a depth of 70 feet bgs. A second water bearing zone exists in fractures at the base of the second basalt flow and is bounded on the bottom by a second clay aquitard at a depth of 150 feet bgs. A third water bearing zone exists in a 50 foot thick deposit of stream gravels and volcanic cinder that directly overlies the Kaibab Formation at a depth of 350 feet bgs. The fourth water bearing zone is the regional aquifer in the Coconino and Supai Formations at a depth of about 1,300 feet bgs.

Ground water recharge to the various water bearing zones occurs along fractures in the basalt flows and through fractures in the underlying Kaibab limestone. The presence and lateral continuity of the aquitards suggests that downward migration does not occur homogeneously throughout the area but is limited to areas of fracturing and faulting. In addition, the existence of the water bearing zones within fractures in the basalt suggests that contaminant migration would not be predictable using standard hydrogeologic techniques. Thus, remediation of contaminants in the ground water within the basalt zones would be problematic.

No drilling was done as part of the investigation of the FAP. Laterally discontinuous perched ground water conditions may exist throughout the alluvium. Drilling northeast, southwest, and east of the site also identified perched ground water within fractures in the basalt overlying the Camp Navajo Clay. Deeper ground water is likely to be present at an approximate depth of 1,300 feet bgs. This is based on the depth to the regional aquifer as measured in the deep water supply well 8,000 feet southwest of the site.

**3.5. GEOPHYSICAL SURVEY**

A line locating survey was conducted around the area to prevent accidental damage to buried utilities in the area during the field investigation. During this survey, all water supply lines and drain lines were identified and marked on the ground surface. No unknown utilities were identified during this survey. Geophysical survey results are included in Appendix D.

## SECTION 4

# NATURE AND EXTENT OF CONTAMINATION

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The following section summarizes the nature and extent of contamination identified at the FAP. All analytical results are tabulated by analysis method in Appendix F. Soil physical characteristics are in Appendix G. Appendix H includes copies of all laboratory reports for this site.

### 4.1. SURFACE SOILS

Concentrations of petroleum hydrocarbons were identified in the surface soil samples collected at this site (Table 4-1). Concentrations of TRPH were detected in all six surface soil samples (up to 6,900 mg/kg) (Figure 4-1). None of the detected concentrations exceeded Arizona Department of Environmental Quality (ADEQ) residential Health Based Guidance Level (HBGL) and thus is not considered to be a contaminant of concern. The other detected petroleum hydrocarbon (Diesel Fuel #2) does not have a set HBGL but was detected at concentrations up to 6,400 mg/kg in eight samples and is evaluated in Section 6.

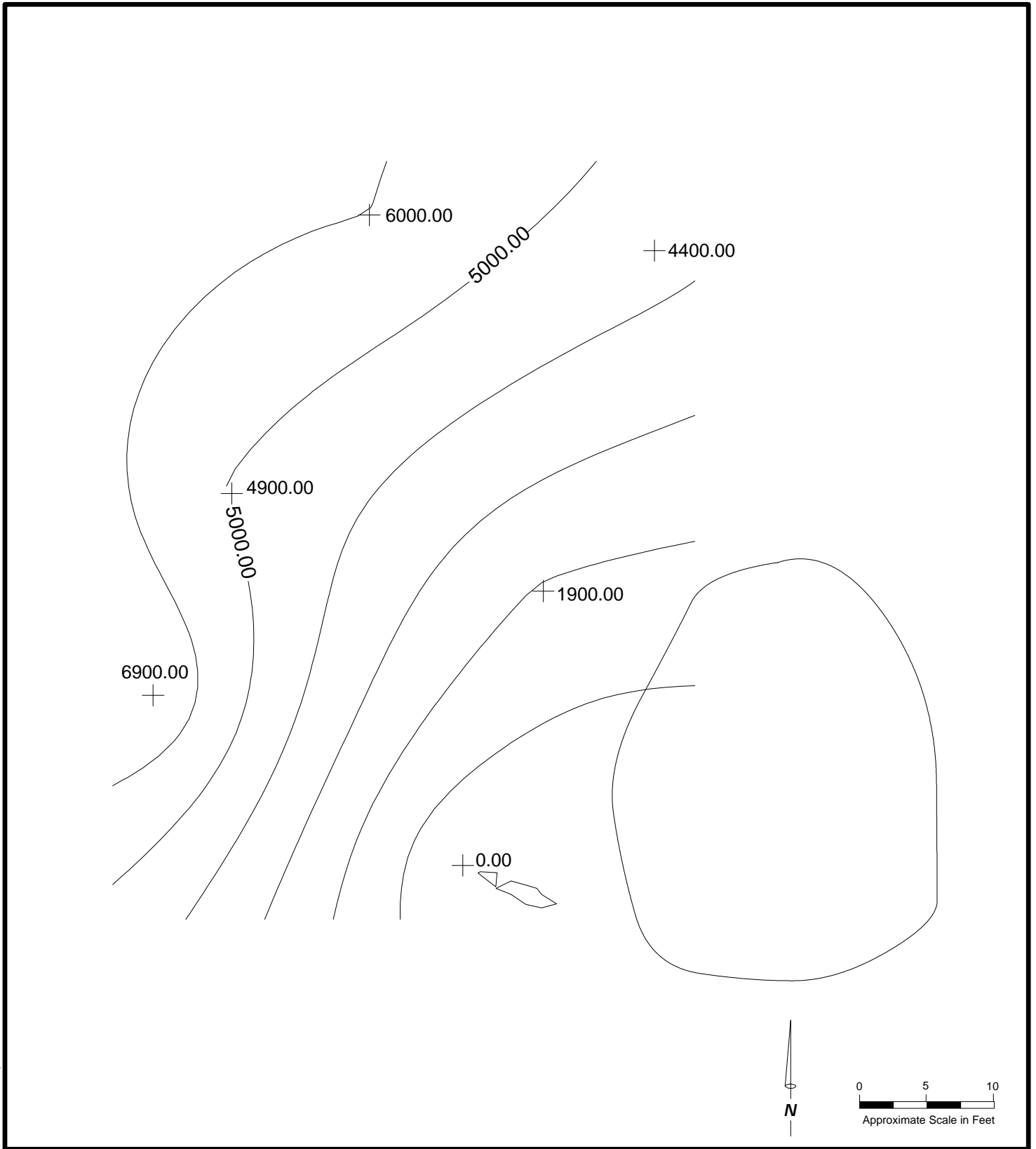
Seventeen SVOCs were identified in surface soil samples collected from the site (Table 4-2). Thirteen SVOCs (naphthalene, acenaphthene, anthracene, benzo(a)-anthracene, benzo(a)pyrene, benzo(b)fluoranthene, bis(2-ethylhexyl)-phthalate, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-c,d)-pyrene, and pyrene) were identified at this site. With three exceptions, the detected concentrations were below the ADEQ nonresidential HBGLs and thus are not considered contaminants of concern. Only benzo(a)anthracene, benzo(a)pyrene, and benzo(b)fluoranthene were detected above ADEQs nonresidential HBGLs. Benzo(a)anthracene was detected in one of the surface soil samples at a concentration above the HBGL (SS01 at 5.6 mg/kg). Benzo(a)pyrene was detected in one of the surface soil samples at a concentration above the HBGL (SS01 at 3.4 mg/kg). Benzo(b)fluoranthene was detected in one of the surface soil samples at a concentration above the HBGL (SS01 at 6.5 mg/kg). The other detected SVOCs (2-methylnaphthalene, benzo(g,h,i)-perylene, dibenzofuran, and phenanthrene) do not have set HBGLs but were detected

**Table 4-1**  
**Former Asphalt Plant Petroleum Hydrocarbon Results**  
 (Detections Only)

Sample ID	Sample Date	Depth	TPH, Recoverable	Diesel Fuel 2
		CRQL	10	10
		Units	mg/kg	mg/kg
FAP-SS01S-01	10/08/1995	1	NA	38 <sup>J+</sup>
FAP-SS02S-01	10/08/1995	1	NA	31 <sup>J</sup>
FAP-SS04S-01	10/08/1995	1	NA	66 <sup>J</sup>
FAP-HA01S-01	10/12/1995	0.5	6900 <sup>J</sup>	120 <sup>J</sup>
FAP-HA01S-02	10/12/1995	2.5	1500	< 0
FAP-HA02S-02	10/12/1995	2.5	15	< 0
FAP-HA03S-01	10/12/1995	0.5	4900	6400 <sup>J</sup>
FAP-HA04S-01	10/12/1995	0.5	1900	86 <sup>J</sup>
FAP-HA05S-01	10/12/1995	0.5	6000	1100 <sup>J</sup>
FAP-HA05S-02	10/12/1995	2.5	81	72 <sup>J</sup>
FAP-HA05S-03	10/12/1995	5	3200	< 0
FAP-HA06S-01	10/12/1995	0.5	4400	66 <sup>J</sup>
FAP-HA06S-02	10/12/1995	2.5	5.6 <sup>J</sup>	< 0
FAP-HA07S-01	10/12/1995	0.5	4 <sup>J</sup>	< 0 <sup>UJ</sup>
Analyses			12	17
Detections			11	9
Maximum Concentration			6900	6400
Arizona HBGL - Nonresidential				
Arizona HBGL - Nonresidential Hits				
Arizona HBGL - Residential			7000	
Arizona HBGL - Residential Hits			0	

## Notes:

CRQL Contract required quantitation limits  
 < Less than the indicated detection limit  
 na not analyzed  
 Data qualifiers are defined in Appendix F



Legend:

—11.70— All concentrations in parts per million (ppm)

**Former Asphalt Plant**  
**TRPH Concentrations in Surface Soils**

Camp Navajo, Bellemont, Arizona

**Table 4-2**  
**Former Asphalt Plant Semivolatile Organic Compounds Results**  
 (Detections Only)

Sample ID	Sample Date	Depth	Naphthalene	2-Methylnaphthalene	Acenaphthene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	bis(2-Ethylhexyl)phthalate	Chrysene	Dibenz(a,h)anthracene	Dibenzofuran	Fluoranthene	Fluorene	Indeno(1,2,3-c,d)pyrene	Phenanthrene	Pyrene
		CRQL Units	0.33 mg/kg	0.33 mg/kg	0.33 mg/kg	0.33 mg/kg	0.33 mg/kg	0.33 mg/kg	0.33 mg/kg	0.33 mg/kg	0.33 mg/kg	0.33 mg/kg	0.33 mg/kg	0.33 mg/kg	0.33 mg/kg	0.33 mg/kg	0.33 mg/kg	0.33 mg/kg	0.33 mg/kg
FAP-SS01S-01	10/08/1995	1	< 0.105	< 0.3	0.15 <sup>J</sup>	2.9 <sup>J</sup>	5.6	3.4	6.5	1.3 <sup>J</sup>	< 0.195	4.9	0.36 <sup>J</sup>	< 0.165	15	0.44 <sup>J</sup>	1.8 <sup>J</sup>	11	14
FAP-SS02S-01	10/08/1995	1	< 0.168	< 0.48	< 0.156	< 0.192	0.46 <sup>J</sup>	< 0.168	0.65 <sup>J</sup>	< 0.252	0.39 <sup>U</sup>	< 0.444	< 0.288	< 0.264	< 0.288	< 0.156	< 0.372	0.47 <sup>J</sup>	0.78 <sup>J</sup>
FAP-SS04S-01	10/08/1995	1	0.14 <sup>J</sup>	0.42 <sup>J</sup>	< 0.026	0.059 <sup>J</sup>	0.12 <sup>J</sup>	0.087 <sup>J</sup>	0.19 <sup>J</sup>	0.061 <sup>J</sup>	< 0.052	0.13 <sup>J</sup>	< 0.048	0.076 <sup>J</sup>	0.2 <sup>J</sup>	< 0.026	< 0.062	0.2 <sup>J</sup>	0.2 <sup>J</sup>
FAP-HA01S-01	10/12/1995	0.5	0.64 <sup>J</sup>	2 <sup>J</sup>	< 0.13	< 0.16	< 0.2	< 0.14	< 0.22	< 0.21	< 0.26	< 0.37	< 0.24	< 0.22	< 0.24	< 0.13	< 0.31	0.28 <sup>J</sup>	< 0.25
FAP-HA01S-02	10/12/1995	2.5	0.026 <sup>J</sup>	0.088 <sup>J</sup>	< 0.013	< 0.016	< 0.02	< 0.014	< 0.022	< 0.021	< 0.026	< 0.037	< 0.024	< 0.022	< 0.024	< 0.013	< 0.031	< 0.015	< 0.025
FAP-HA03S-01	10/12/1995	0.5	2.4 <sup>J</sup>	5.5 <sup>J</sup>	< 0.195	< 0.24	< 0.3	< 0.21	< 0.33	< 0.315	< 0.39	< 0.555	< 0.36	< 0.33	< 0.36	0.31 <sup>J</sup>	< 0.465	0.47 <sup>J</sup>	< 0.375
FAP-HA05S-01	10/12/1995	0.5	< 0.294	< 0.84	< 0.273	< 0.336	< 0.42	< 0.294	< 0.462	< 0.441	< 0.546	< 0.777	< 0.504	< 0.462	< 0.504	< 0.273	< 0.651	0.38 <sup>J</sup>	< 0.525
Analyses			17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
Detections			4	4	1	2	3	2	3	2	1	2	1	1	2	2	1	6	3
Maximum Concentration			2.4	5.5	0.15	2.9	5.6	3.4	6.5	1.3	0.39	4.9	0.36	0.076	15	0.44	1.8	11	14
Arizona HBGL - Nonresidential			16450		24500	122500	4.6	0.8	4.6		407	462	0.46		16450	16450	4.6		12250
Arizona HBGL - Nonresidential Hits			0		0	0	1	1	1		0	0	0		0	0	0		0

Notes:

CRQL Contract required quantitation limits  
 < Less than the indicated detection limit  
 Data qualifiers are defined in Appendix F

at very low concentrations (5.5 mg/kg, 1.3 mg/kg, 0.076 mg/kg, 11 mg/kg, respectively) and are evaluated in Section 6.

#### 4.2. SUBSURFACE SOILS

Concentrations of petroleum hydrocarbons were identified in the subsurface soil samples collected at this site (Table 4-1). Concentrations of TRPH were detected in all five subsurface soil samples (up to 3,200 mg/kg) (Figure 4-2). None of the detected concentrations exceeded ADEQ residential HBGL and thus is not considered to be a contaminant of concern. The other detected petroleum hydrocarbon (Diesel Fuel #2) does not have a set HBGL but was detected at concentrations up to 72 mg/kg in one sample and is evaluated in Section 6.

Two SVOCs were identified in subsurface soil samples collected from the site (Table 4-2). One SVOC (naphthalene) was identified at a concentration below ADEQ nonresidential HBGL and thus is not considered to be a contaminant of concern. The other detected SVOC (2-methylnaphthalene) does not have a set HBGLs but was detected at very low concentrations (0.088 mg/kg) and is evaluated in Section 6.

#### 4.3. QA/QC

All samples were sent to Quanterra for inorganic and organic parameter analyses. Temperature blanks for all coolers forwarded to the laboratory were within an acceptable range and all coolers arrived with custody seals intact. Applicable holding times were met for all analyses. Two field duplicate samples, including one surface soil (SS) and one subsurface soil (HA) sample, were collected at the site during the investigation, as shown below. Validation of the data was conducted by Laboratory Data Consultants, Inc., (LDC) of Carlsbad, California:

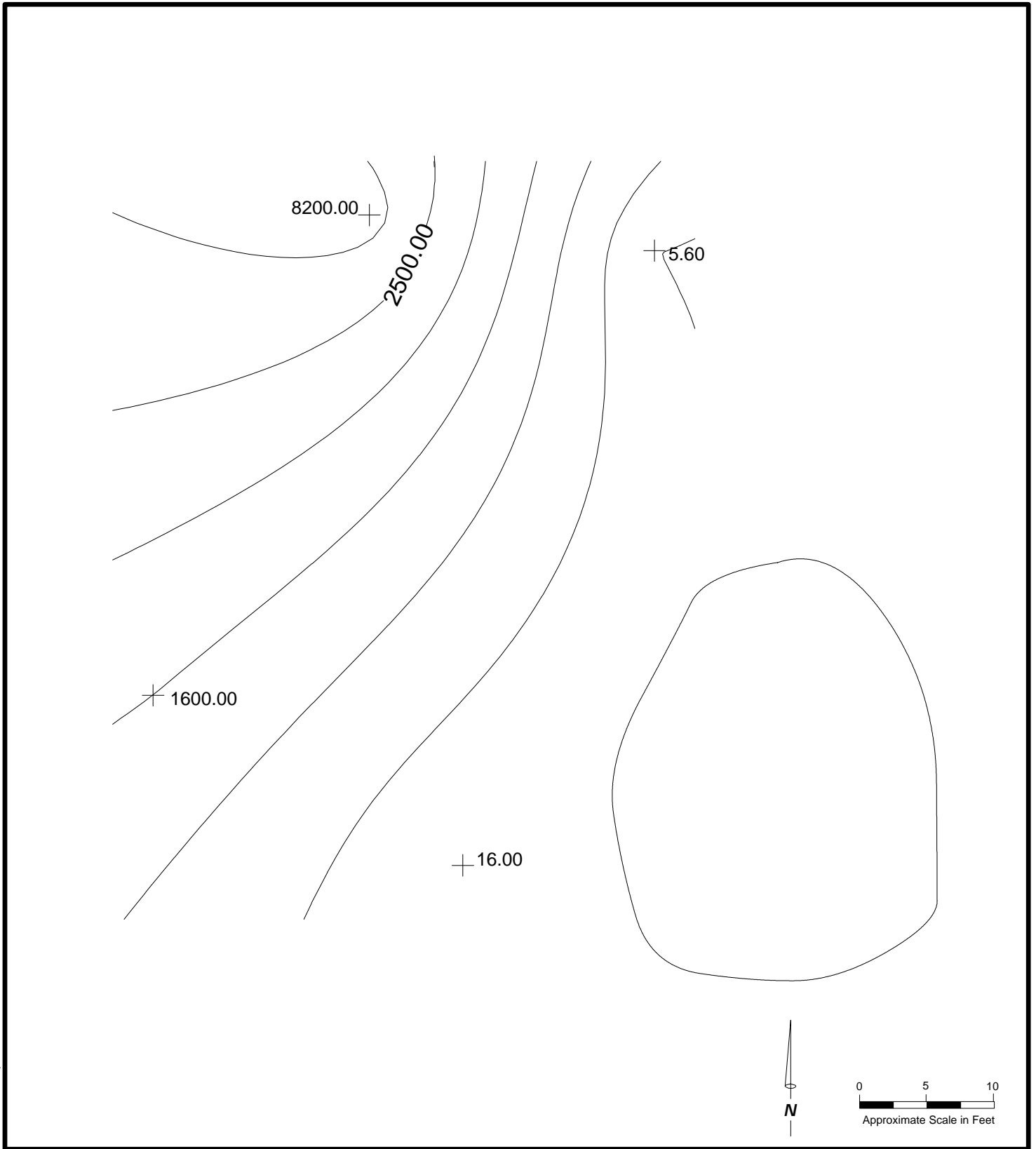
- FAP-SS05S-01 blind duplicate of FAP-SS03S-01; and,
- FAP-HA07S-01 blind duplicate of FAP-HA01S-01.

General validation findings applicable to organic data resulted in the qualification of select compound concentrations above the method detection limit but below the respective sample quantitation limit prior to dilution and percent moisture corrections. These reported values are considered to be qualitatively acceptable but quantitatively estimated due to uncertainties in analytical precision near the limit of detection. According to USEPA guidelines, however, these low concentration data are considered suitable for risk evaluation applications with appropriate recognition of the noted quantitative uncertainties.

##### ***Semivolatile Organic Compounds by USEPA Method 8270B***

Evaluation of field duplicate results for the SVOC analyses indicated excellent qualitative and quantitative agreement between reported results. All analytical





Legend:

—11.70— All concentrations in parts per million (ppm)

***Former Asphalt Plant***  
***TRPH Concentrations in Subsurface Soils***

Camp Navajo, Bellemont, Arizona

values reported for the field duplicate pairs involved trace concentrations either at or below the respective sample quantitation limits; hence, all SVOC duplicate results are considered acceptable.

Results of the validation performed by LDC indicated potential quantitative uncertainties in nondetect SVOC results for numerous surface and subsurface soil samples based on calibration parameters exceeding data assessment criteria. Analytical data for the associated samples indicated in Appendix E were flagged as quantitatively estimated. Affected SVOCs included the following: 1,2,4,5-tetrachlorobenzene, 2,3,4,5-tetrachlorobenzene, 2-naphthylamine, 2-picoline, 3,3'-dichlorobenzidine, 4-aminobiphenyl, 4-nitrophenol, a,a-dimethylphenethylamine, ethylmethanesulfonate, hexachlorocyclopentadiene, n-nitroso-di-n-butylamine, n-nitrosodimethylamine, pentachlorobenzene, and pentachloronitrobenzene.

The compounds indicated above have no calibration specifications required by the method, and all affiliated matrix spike (MS) and laboratory control sample (LCS) recoveries were within QC acceptance criteria. Moreover, the magnitude of any potential quantitative biases would likely be insignificant relative to the respective health-based limits established for each compound. Hence, applicable nondetect SVOC results are considered quantitatively estimated but are not expected to adversely impact risk evaluation objectives for the site.

In addition, validation findings indicated severe quantitative uncertainties with nondetect benzidine results for multiple surface and subsurface soil samples based on relative response factors below minimum QC acceptance criteria for sensitivity. Impacted sample data are indicated in Appendix E. Although the laboratory satisfied all operational calibration requirements for benzidine, associated results have been qualified as rejected based on USEPA data assessment criteria for SVOC analyses. Affected benzidine results are thus considered invalid and unusable for all risk evaluation purposes.

All other SVOC data for submitted field samples were determined to be valid without qualification and were considered usable for all purposes.

***Total Extractable Petroleum Hydrocarbons by ADHS Method BLS-191***

Evaluation of field duplicate data for the total extractable petroleum hydrocarbon (TEPH) analyses indicated variable quantitative agreement between reported results. Statistical precision among surface soil duplicates was deemed acceptable, while the relative percent difference (RPD) calculated for subsurface data was significantly outside QC acceptance criteria established for the program. This incident of imprecision is likely attributable both to the degraded nature and nonhomogenous subsurface distribution of the petroleum hydrocarbon contamination as well as to the high clay content and typical heterogeneity of soils in the Camp Navajo area. Although USEPA guidelines for organic data assessment do not require qualification of data on the basis of field duplicate precision alone, TEPH results for the indicated

samples were flagged as quantitatively estimated in Appendix E. However, no restrictions on TEPH data usability for risk evaluation applications are expected.

Validation findings indicated a general qualitative uncertainty in reported TEPH results associated with identification of the hydrocarbon species. Quantification of TEPH results was accomplished using diesel fuel reference standards since chromatographic profiles observed in sample analyses were not consistent with patterns obtained from known hydrocarbon reference standards. Due to both the default application of diesel fuel reference factors and the high degree of uncertainty in the petroleum hydrocarbon identifications, the resulting nonspecified TEPH values in both surface and subsurface soils are considered quantitatively estimated and are reported as unknown hydrocarbons.

All other TEPH data for submitted samples were determined to be valid without qualification and were considered usable for all purposes.

***Total Recoverable Petroleum Hydrocarbons by ADHS Method BLS-418.1AZ***

Evaluation of field duplicate results for the total recoverable petroleum hydrocarbon (TRPH) analyses indicated poor quantitative agreement between reported results. Similar to results obtained from the TEPH analyses, field duplicate precision calculated for subsurface data was significantly outside QC acceptance criteria. As noted, this incident of imprecision is likely attributable both to the degraded nature and nonhomogenous subsurface distribution of the petroleum hydrocarbon contamination, as well as to the high clay content and typical heterogeneity of soils in the Camp Navajo area. Although USEPA guidelines for organic data assessment do not require qualification of data on the basis of field duplicate precision alone, TRPH results for the indicated samples were flagged as quantitatively estimated in Appendix E. However, no restrictions on TRPH data usability for risk evaluation applications are expected.

All other TRPH data for submitted samples were determined to be valid without qualification and were considered usable for all purposes.

***Total Organic Carbon by Modified USEPA 9060 (Walkley-Black Methodology)***

TOC analyses were not performed for the designated field duplicate pair; therefore, no TOC field duplicate data from the site were available for review. Since TOC data from the program are to be used exclusively for remediation rather than for health evaluation purposes, no impact on overall data quality objectives for the site is expected. All other TOC data for submitted samples were determined to be valid without qualification and were considered useable for all purposes.

#### **4.4. INTERIM REMOVAL ACTIONS**

Under contract with the USACE, Morrison Knudsen Corporation (MK) was tasked to remove the polycyclic aromatic hydrocarbons (PAHs) contamination at the site (Appendix I).

On October 4, 1996, an eight-foot by eight-foot area was excavated around Tetra Tech's sample SS01 and a 25-foot by 15-foot area was excavated around HA03. Both locations were excavated to an average depth of 12 inches. Approximately 50 tons of asphalt were removed and disposed of before the underlying soils were excavated. After removal of the asphalt, approximately 40 tons of contaminated soil was placed in lined bins. MK backfilled the excavations with on-site fill material, as directed by the AZNG.

Five confirmation samples were taken from the two excavations and were analyzed for TRPH, TPH-d, and benzene, toluene, ethylbenzene, and xylene (BTEX). No detectable concentrations of BTEX were found, and minor concentrations of TPH-d were found. One soil sample (38) contained concentrations of TRPH above nonresidential HBGLs (Table 4-3). An additional eight inches of soil was excavated around that sample, and another two confirmation samples were analyzed. No detectable concentrations of TRPH were found.

On May 13, 1997, two additional samples were taken from a depth of three feet and were analyzed for PAHs. No detectable concentrations of PAHs were found.

**Table 4-3**  
**Former Asphalt Plant Results**  
 (petroleum hydrocarbons only)

Sample ID	Sample Date	Depth	TPH, Recoverabl	Diesel Fuel 2
		CRQL	10	10
		Units	mg/kg	mg/kg
36			< 20	< 10
37			25	< 10
38			31240	6800
39			96	< 10
40			545	40
54			< 20	na
55			< 20	na
Analyses			7	7
Detections			4	2
Maximum Concentration			31240	6800
Arizona HBGL - Nonresidential				
Arizona HBGL - Nonresidential Hits				
Arizona HBGL - Residential			7000	
Arizona HBGL - Residential Hits			1	

## Notes:

CRQL Contract required quantitation limits

## SECTION 5

# CONTAMINANT FATE AND TRANSPORT

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Section 4 discussed the potential contaminants of concern for the former asphalt plant site soils and ground water. The contaminants of concern in the site soils were identified as benzo(b)fluoranthene, benzo(a)pyrene, and benzo(a) anthracene. This section provides a summary of the potential routes of migration, the ability to persist in the environment, and the relative migration potential for these contaminants of concern.

### 5.1. POTENTIAL ROUTES OF MIGRATION

The same potential routes of migration exist for organic and inorganic compounds in soils. The contaminants can become dissolved in infiltrating precipitation and be transported vertically downward. This process can be quite rapid where near vertical open channels, such as solution planes or fractures, exist. Overland routes of migration include transport by wind as particulates, hydraulic transport in a surface water body, or excavation and transport by humans or animals.

### 5.2. CONTAMINANT PERSISTENCE

Benzo(b)fluoranthene, benzo(a)pyrene, and benzo(a)anthracene are PAHs, which are formed by the incomplete burning of organic compounds, primarily oil, coal, and gas. Microbial metabolism is the primary mechanism for degradation of PAHs in soils. The rate and extent of degradation are influenced by factors such as temperature, pH, soil contamination, moisture, nutrients, soil type, and the presence of cometabolites (Sims and Overcash 1983). Metabolism of PAHs by bacteria and fungi includes a series of breakdown compounds resulting in the formation of acetaldehyde and acetic, fumaric, pyruvic, and succinic acids. The rate of biodegradation can be influenced by the degree of soil contamination. In general, more highly contaminated soils retard the process. This may be in part due to the fact that other contaminants are toxic to microorganisms.

In a saturated environment, PAHs can be significantly degraded under aerobic conditions; however, under anaerobic conditions the degradation rate is extremely

slow (Neff 1979). Microorganisms in stored aerobic ground water samples completely degraded PAHs in three days. However, there was no indication of degradation in the anaerobic aquifer from which the samples were collected (Ogawa et al. 1982).

### 5.3. CONTAMINANT MIGRATION

Organic compounds also are subject to adsorption onto soil particle surfaces. A few key factors allow the estimation of the relative mobility of the contaminants. The polar-ionic character of the compound affects sorption; in clayey sediments the more polar compounds will be adsorbed at a higher rate. The octanol water coefficient ( $K_{ow}$ ) represents the distribution of a chemical between octanol and water in contact at equilibrium conditions. In general,  $K_{ow}$  is a measure of the hydrophobicity of an organic compound in water. The more hydrophobic it is, the higher the  $K_{ow}$ . Thus the compound will be more likely to partition onto soils and will have a lower solubility in water.

The soil organic carbon/water partition coefficient ( $K_{oc}$ ), is defined as the adsorbed chemical per gram of organic carbon, divided by the micrograms of chemical per milliliter of solution. It is based on the assumption that the soil's organic content is the only determinant of the sorption rate of a compound from water to soil. The total organic carbon fraction for the former asphalt plant site soils is generally less than one percent, indicating that the adsorption rate is low and the mobility of the contaminants will be relatively high.

The properties of organic compounds observed above nonresidential HBGLs in soils at the former asphalt plant site are given on [Table 5-1](#). The  $K_{ow}$  and  $K_{oc}$  values are relatively high, indicating relatively low mobility in ground water and their tendency to sorb onto organic carbon. In addition, the low solubilities would further inhibit the rate of transport in a ground water system. For these reasons, the PAH contaminants of concern are not expected to be significantly mobile.

**Table 5-1**  
**Selected Properties of Polycyclic Aromatic Hydrocarbons Compounds**

Property	benzo(a) anthracene	benzo(b) fluoranthene	benzo(a) pyrene
Density (g/cm <sup>3</sup> )	1.27	no data found	1.35
Water solubility mg/l @ 25°C	0.014	0.0012	0.0038
log $K_{oc}$	6.14	5.74	6.00
log $K_{ow}$	5.61	6.57	5.99

## SECTION 6

# RISK SCREENING

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Current activities and activity patterns at the site are considered commercial/industrial, as are the documented uses of land surrounding the site. Therefore, for purposes of this risk screening, land use of the site is assumed to be industrial. Previous operations at the site have indicated SVOCs and petroleum hydrocarbons to be the principal chemicals of concern (COCs) posing a potential exposure risk to workers involved in commercial/industrial activities on-site. With the exception of several semivolatile PAHs, laboratory results for organic COCs show that maximum soil concentrations are below current HBGLs developed by the Arizona Department of Health Services (ADHS) using nonresidential exposure assumptions in all situations where HBGLs have been established.

Three PAHs, benzo(a)anthracene, benzo(a)pyrene, and benzo(b)fluoranthene, were detected in soils at concentrations greater than both the corresponding nonresidential HBGLs developed by ADHS and the preliminary remediation goals (PRGs) established by USEPA Region IX for industrial soils. Moreover, three other PAHs without currently established HBGLs or PRGs also were detected in surface soils at comparable levels. While each of these compounds had a relatively low overall frequency of detection at the site, their detections all occurred in the surface, rather than subsurface, soil layer. Considering the potential for intermedia transfer of contaminants in commercial/industrial settings via the dispersion of entrained particles and fugitive dust, it cannot be concluded that detected PAH levels present an acceptable risk to on-site occupational activities.

In addition, the three PAHs detected at levels above the respective ADHS HBGLs are all categorized as potential carcinogens by the USEPA. Benzo(a)pyrene, detected in two of the five surface soil samples tested, represents the standard compound for comparative toxicity among carcinogenic PAHs, according to both USACE and USEPA relative-risk guidelines. Current USEPA guidance on the characterization of risk from short-term exposures to carcinogens also indicates that any exposure, regardless of duration, may result in carcinogenic risk. Likewise, USEPA risk



assessment guidelines require the summation of chemical-specific cancer risks when multiple carcinogenic COCs have been detected. From a quantitative risk screening perspective using USEPA carcinogenic “total risk” criteria and based on available site data, reported PAH concentrations in surface soils are not considered to reside within an acceptable cumulative risk range under expected exposure conditions.

Although there is no current nonresidential HBGL developed by ADHS for dibenzofuran, its maximum concentration (0.076 mg/kg) reported for on-site soils was found to be significantly less than the PRG (140 mg/kg) established by USEPA for industrial soils. Therefore, this compound is not indicated to be present at concentrations high enough to pose a potential exposure or health threat during on-site commercial/industrial activities using USEPA Region IX guidelines.

Petroleum hydrocarbon data reported for surface and subsurface soil samples revealed generalized, low to mid-level concentrations consistent with historical operations at the site. Although there were no TPRH concentrations among the 17 analyses reported above the respective ADHS HBGL, several subsurface soil samples indicated petroleum hydrocarbon contamination approaching health-based action levels. For the TEPH analyses, a method without HBGLs established by ADHS, reported soil concentrations were all less than the comparable HBGL established for TRPH.

Lastly, all TEPH results greater than the respective sample quantitation limit were reported by the laboratory as unknown hydrocarbons, and no surface or subsurface soil sample had detectable diesel fuel concentrations. Since USEPA and USACE guidelines require the use of chemical-specific data in deriving estimates of potential health risks, TRPH and TEPH data from the site present qualitative evidence of low to mid-level, principally subsurface, hydrocarbon contamination at concentrations not expected to be health-adverse. As such, identified chemical constituents of petroleum products detected at the site, namely the PAHs indicated above, remain the primary toxicological concern pertinent to commercial/industrial activities.

#### **6.1. RISK ASSESSMENT SUMMARY**

A group-wide risk assessment for Group B-3 including a quantitative evaluation of the Former Asphalt Plant, was prepared in January 1998 (Tetra Tech 1999c). The results of the risk assessment concurred with the risk screening above. No excess carcinogenic risks ( $>10^{-6}$ ) were identified in relation to surface soils or near surface soils. No evaluated noncarcinogenic hazard indices ( $>1$ ) were identified in relation to surface soils or near surface soils. There is no primary contributor to carcinogenic risks and noncarcinogenic hazard indices in surface and near-surface soils. There is no primary contributor to carcinogenic risks and noncarcinogenic hazard indices in ground water. The ecological risk action level for a selected wildlife indicator species was not exceeded.

# SECTION 7

## SUMMARY AND CONCLUSIONS

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### 7.1. SUMMARY

Seventeen organic compounds were detected in soil samples collected at the former asphalt plant. Most of the contaminants were detected at concentrations below HBGLs or established background levels.

Contaminants of concern identified in surface soil samples included benzo(a)anthracene (up to 5.6 mg/kg), benzo(a)pyrene (up to 3.4 mg/kg), and benzo(b)fluoranthene (up to 6.5 mg/kg). Soils associated with these samples were excavated and disposed of by MK in October 1996.

No contamination above action levels remain at the former asphalt plant. Remaining concentrations of contaminants do not exceed risk-based concentrations of concern.

### 7.2. CONCLUSIONS

Risk evaluation results indicate that the maximum reported concentrations of identified contaminants remains in surface and subsurface soils at the site would not be expected to result in adverse health effects relevant to commercial/industrial land use.

All data collected during this investigation meet QA/QC standards and are considered to be representative of site conditions. Therefore, based on the lack of detected contamination remaining at the site at concentrations exceeding either HBGLs or risk screening levels, Tetra Tech recommends the site for consideration for closure by ADEQ.

## SECTION 8

## REFERENCES

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**APPENDIX A**  
PHOTO DOCUMENTATION

3-11 Former Asphalt Plant, NE, 7/20/94, by Brad Hall

3-12 Former Asphalt Plant, N, 7/20/94, by Brad Hall









## **APPENDIX B**

### FIELD NOTES

## **APPENDIX C**

### STANDARD OPERATING PROCEDURES

# SECTION 1

## SURFACE-SOIL SAMPLING

---

### 1.1 PURPOSE

The purpose of this standard operating procedure (SOP) is to describe the considerations and procedures for collecting representative surface samples. Analysis of surface samples can determine whether concentrations of specific surface pollutants exceed established action levels, and if the concentrations of soil pollutants present a risk to public health, welfare, or the environment.

Materials exposed on the land surface, including soils, sediments, and wastes, are subject to disturbance by weather conditions, vehicle traffic, bioturbation, and other effects. Because volatile contaminants are unlikely to be present in surficial materials, it generally is not necessary to obtain undisturbed samples from the surface. An exception to is when surface samples are collected from beneath an impermeable surface, such as a road or building slab. Surface soils are typically very heterogeneous in compositions and texture, and chemical concentrations in surface soils may vary dramatically over short depth intervals. Often, the first few inches of soil contain gravel, vegetation, or debris. It is desirable to use a sampling method that reduces the impacts of these heterogeneities without biasing the results.

For surface-soil sampling, some judgment may be needed to identify the ground surface datum. The objective is to sample the soil matrix and avoid collecting rock and plant material to the extent possible. Vegetation will be moved aside, dense vegetative matting, detritus or roots will be removed, and gravel will be scraped away to expose the ground surface. Surface samples from beneath pavement or concrete slabs will be collected after first removing road base and gravel to expose the underlying soil. In some locations, such as in the basements of buildings, the ground surface will be below grade. In these cases, depth below grade will be measured and recorded.

## **1.2 TECHNIQUE - DESCRIPTION**

Soil samples may be collected using a variety of methods and equipment. The methods and equipment used are dependent on the type of sample required (disturbed versus undisturbed) and the type of soil. Samples that do not need to be undisturbed may be easily sampled using a spade, trowel, or scoop. Collecting undisturbed samples may be performed using a hand-auger, a trier, or a split-spoon sampler.

## **1.3 PROCEDURES**

### **1.3.1 Preparation**

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are required.
2. Obtain necessary sampling and air monitoring equipment.
3. Decontaminate or preclean equipment, and ensure that it is in working order.
4. Prepare schedules, and coordinate with staff, client, and regulatory agencies as appropriate.
5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.
6. Use stakes, buoys, or flagging to identify and mark all sampling locations. Consider specific site factors, including extent and nature of contaminant, when selecting sample location. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. All staked locations will be cleared for underground utilities by the property owner prior to soil sampling.

### **1.3.2 Interferences and Potential Problems**

There are two primary interferences or potential problems associated with soil sampling. These are cross-contamination of samples and improper sample collection methods. Cross-contamination can be eliminated or minimized through the use of sampling equipment dedicated to each sample location. If this is not possible or practical, then decontamination of sampling equipment is necessary. Improper sample collection methods include using contaminated sampling equipment, disturbing of the matrix causing in compaction of the sample, or inadequate homogenizing of the samples where required, which results in variable, non-representative analytical results.

### **1.3.3 Sampling Considerations**

This method can be used in most soil types. Surface soil samples may be collected with spades, shovels, or scoops. Surface material can be removed to the required depth with this equipment, then a stainless steel or plastic scoop can be used to collect the sample.

Accurate, representative samples can be collected with this procedure depending on the care and precision taken. A flat, pointed mason trowel can be used to cut a block of the desired soil when undisturbed profiles are required. A stainless steel scoop, lab spoon, or plastic spoon will suffice in most other cases. Avoid the use of devices plated with chrome or other materials. Plating is particularly common with garden implements such as potting trowels.

Follow these procedures to collect surface-soil samples.

1. Carefully remove the top layer of soil or debris to the desired sample depth with a pre-cleaned spade.
2. Using a pre-cleaned, stainless-steel scoop, plastic spoon, or trowel, remove and discard a thin layer of soil from the area which came in contact with the spade.
3. If the sample is to be analyzed for volatile organics, volatile organic analysis is to be performed, transfer a portion of the sample directly into an appropriate, labeled sample container(s) with a stainless-steel lab spoon, plastic lab spoon, or equivalent and secure the cap(s) tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogeneous sample representative of the entire sampling interval. Then, place the sample into an appropriate, labeled container(s) and secure the cap(s) tightly.

#### **1.3.4 Sample Containers and Preservation Techniques**

In order to ensure proper sample preservation, samples should be refrigerated to 9°C or less and holding time should be kept to a minimum.

#### **1.3.5 Field Quality Control Sampling Procedures**

There are no specific quality-assurance activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

- All data must be documented on field data sheets or within site logbooks.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior and after sampling/operation and they must be documented.

#### **1.3.6 Decontamination Procedures**

All sample equipment that comes into contact with soil or water must be decontaminated prior to sampling. Decontamination procedures for sampling equipment are described in the Decontamination of Field Equipment SOP.

## SECTION 2

# SHALLOW SUBSURFACE-SOIL SAMPLING

---

### 2.1 PURPOSE

The purpose of this standard operating procedure (SOP) is to describe the considerations and procedures for collecting representative shallow subsurface soil samples. Analysis of shallow subsurface samples can determine whether concentrations of specific subsurface pollutants exceed established action levels, and if the concentrations of soil pollutants present a risk to public health, welfare, or the environment.

Because volatile contaminants are likely to be present in subsurface materials, it generally is necessary to obtain undisturbed samples from the subsurface. Subsurface soils are typically very heterogeneous in compositions and texture, and chemical concentrations in subsurface soils may vary dramatically over short depth intervals.

### 2.2 TECHNIQUE - DESCRIPTION

Subsurface soil samples may be collected using a variety of methods and equipment. The methods and equipment used are dependent on the depth of the desired sample, the type of sample required (disturbed versus undisturbed), and the type of soil. Near-surface soils may be easily sampled using a spade, trowel, or scoop. Sampling at greater depths may be performed using a hand-auger, a trier, a split-spoon sampler, or, if required, a backhoe.

### 2.3 PROCEDURES

#### 2.3.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are required.
2. Obtain necessary sampling and air monitoring equipment.
3. Decontaminate or preclean equipment, and ensure that it is in working order.

4. Prepare schedules, and coordinate with staff, client, and regulatory agencies as appropriate.
5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.
6. Use stakes, buoys, or flagging to identify and mark all sampling locations. Consider specific site factors, including extent and nature of contaminant, when selecting sample location. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. All staked locations will be cleared for underground utilities by the property owner prior to soil sampling.

### 2.3.2 Interferences and Potential Problems

There are two primary interferences or potential problems associated with subsurface soil sampling. These are cross-contamination of samples and improper sample collection methods. Cross-contamination can be eliminated or minimized through the use of sampling equipment dedicated to each sample location. If this is not possible or practical, then decontamination of sampling equipment is necessary. Improper sample collection methods include using contaminated sampling equipment, disturbing of the matrix causing in compaction of the sample, or inadequate homogenizing of the samples where required, which results in variable, non-representative analytical results.

### 2.3.3 Sampling Considerations

#### ***Sampling at Depth with Augers and Thin-Wall Tube Samplers***

This system consists of an auger, a series of handle extensions to allow sampling at depth, a “T” handle, and a thin-wall tube sampler. The auger is used to bore a hole to a desired sampling depth, and is then withdrawn. The sample may be collected directly from the auger. If a core sample is to be collected, the auger tip is then replaced with a thin-wall tube sampler. The sampler is then lowered down the borehole and driven into the soil at the completion depth. The sampler is then withdrawn and the core removed.

Several types of augers are available. These include: bucket, continuous flight (screw), and posthole augers. Bucket augers are better for direct sample recovery since they can remove a large volume of sample in a short time. When continuous flight augers are used, the sample can be collected directly from the auger flights. Sampling from continuous flight augers is satisfactory when a composite of the complete soil column is desired. Posthole augers have limited utility for sample collection.

Follow these procedures for collecting subsurface soil samples with the auger and a thin-wall tube sampler.

1. Attach the auger bit to a drill rod extension, and attach the “T” handle to the drill.

2. Clear the area to be sampled of any surface debris (e.g. twigs, rocks, litter). It may be advisable to remove the first 3 to 6 inches of surface soil for an area approximately 6 inches in radius around the drilling location.
3. Begin augering, periodically removing and depositing accumulated soils onto a plastic sheet spread near the hole. This helps prevent accidental brushing of loose material back down the borehole when removing the auger or adding extensions. It also facilitates refilling the hole, and avoids possible contamination of the surrounding area.
4. After reaching the desired depth, slowly and carefully remove the auger from boring. When sampling directly from the auger, collect sample after the auger is removed from boring and proceed to step 10.
5. Remove auger tip from drill rods and replace with a pre-cleaned thin-wall tube sampler. Install proper cutting tip.
6. Carefully lower the tube sampler down the borehole. Gradually force the tube sampler into the soil. Care should be taken to avoid scraping the borehole sides. Avoid hammering the drill rods to facilitate coring as the vibrations may cause the boring walls to collapse.
7. Remove the tube sampler, and unscrew the drill rods.
8. Remove the cutting tip and the core from the device.
9. Discard the top of the core (approximately 1 inch), as this represents material collected before penetration of the layer of concern. Place the remaining core into the appropriate labeled sample container(s). Sample homogenization is not required.
10. If volatile organic analysis is to be performed, transfer portion of the sample directly into an appropriate, labeled container(s) with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap(s) tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogeneous sample representative of the entire sampling interval. Then, place the sample into an appropriate, labeled container(s) and secure the cap(s) tightly.
11. If another sample is to be collected in the same hole, but at a greater depth, reattach the auger bit to the drill and assembly, and follow steps 3 through 11, making sure to decontaminate the auger and tube sampler between samples.
12. Abandon the hole according to applicable state regulations. Generally, shallow holes can simply be backfilled with the removed soil material.



***Sampling at Depth with a Trier***

The system consists of a trier, and a “T” handle. The auger is driven into the soil to be sampled and used to extract a core sample from the appropriate depth.

Follow these procedures to collect subsurface soil samples with a sampling trier.

1. Insert the trier into the material to be sampled at a 0° to 45° angle from horizontal. This orientation minimizes the spillage of sample.
2. Rotate the trier once or twice to cut a core of material.
3. Slowly withdraw the trier, making sure that the slot is facing upward.
4. If volatile organic analysis is to be performed, transfer portion of the sample directly into an appropriate, labeled container(s) with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap(s) tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogeneous sample representative of the entire sampling interval. Then, place the sample into an appropriate, labeled container(s) and secure the cap(s) tightly.

***Sampling at Depth with a Split-Spoon Sampler***

The procedure for split-spoon sampling describes the collection and extraction of undisturbed soil cores of 18 or 24 inches in length. A series of consecutive cores may be extracted with a split spoon sampler to give a complete soil column profile, or an auger may be used to drill down to the desired depth for sampling. The split spoon is then driven to its sampling depth through the bottom of the augered hole and the core extracted.

When split-tube sampling is performed to gain geologic information, all work should be performed in accordance with ASTM D 1586-84.

Follow these procedures for collecting subsurface soil samples with a split spoon.

1. Assemble the sampler by aligning both sides of the barrel and then screwing the bit onto the bottom and the heavier head piece onto the top.
2. Place the sampler in a perpendicular position on the sample material.
3. Using a sledge hammer or well ring, if available, drive the tube. Do not drive past the bottom of the head piece or compression of the sample will result.
4. Record in the site logbook or on field data sheets the length of the tube used to penetrate the material being sampled, and the number of blows required to obtain this depth.

5. Withdraw the sampler, and open by unscrewing the bit and head and splitting the barrel. If a split sample is desired, a cleaned, stainless steel knife should be used to divide the tube contents in half longitudinally. The split-spoon sampler typically is available in diameters of 2 and 3 1/2 inches. A larger barrel may be required to obtain the required sample volume.
6. Without disturbing the core, transfer it to an appropriate labeled sample container(s) and seal tightly.

#### **2.3.4 Sample Containers and Preservation Techniques**

In order to ensure proper sample preservation, samples should be refrigerated to 9°C or less and holding time should be kept to a minimum.

#### **2.3.5 Field Quality Control Sampling Procedures**

There are no specific quality-assurance activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

- All data must be documented on field data sheets or within site logbooks.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior and after sampling/operation and they must be documented.

#### **2.3.6 Decontamination Procedures**

All sample equipment that comes into contact with soil or water must be decontaminated prior to sampling. Decontamination procedures for sampling equipment are described in the Decontamination of Field Equipment SOP.

## **APPENDIX D**

### **GEOPHYSICAL SURVEY RESULTS**

## **APPENDIX E**

### **SURVEYOR RESULTS**

SiteID	PTID	Northing	Easting	Elevation
FAP	SS01	27262.82	20214.2	
FAP	SS02	27258.16	20227.35	
FAP	SS03	27224.04	20218.94	
FAP	SS04	27236.16	20198.04	
FAP	HA01	27292.55	20186.73	
FAP	HA02	27279.92	20209.73	
FAP	HA03	27307.54	20192.57	
FAP	HA04	27300.29	20215.71	
FAP	HA05	27328.21	20202.79	
FAP	HA06	27325.57	20223.96	

**APPENDIX F**  
ANALYTICAL RESULTS TABLE

# Analyses

Sample ID	Sample Date	Depth (feet)	Media	Percent Water ASTM D2216	pH SW9045B	Total Organic Carbon WBLACK	Redox Potential ASTM D1498	Dry Density ASTM D2937	Particle-Size Distribution ASTM D422	Petroleum Hydrocarbons BLS-191	Petroleum Hydrocarbons BLS-418 1 AZ	Semivolatile Organic Compounds SW8270B
FAP-SS01S-01	10/08/1995	1	Soil	X	X					X		X
FAP-SS02S-01	10/08/1995	1	Soil	X	X					X		X
FAP-SS03S-01	10/08/1995	1	Soil	X	X	X	X	X	X	X		X
FAP-SS04S-01	10/08/1995	1	Soil	X	X					X		X
FAP-SS05S-01*	10/08/1995	1	Soil	X	X					X		X
FAP-HA01S-01	10/12/1995	0.5	Soil	X	X	X	X			X	X	X
FAP-HA01S-02	10/12/1995	2.5	Soil	X	X					X	X	X
FAP-HA02S-01	10/12/1995	0.5	Soil	X	X					X	X	X
FAP-HA02S-02	10/12/1995	2.5	Soil	X	X					X	X	X
FAP-HA03S-01	10/12/1995	0.5	Soil	X	X					X	X	X
FAP-HA04S-01	10/12/1995	0.5	Soil	X	X					X	X	X
FAP-HA05S-01	10/12/1995	0.5	Soil	X	X					X	X	X
FAP-HA05S-02	10/12/1995	2.5	Soil	X	X					X	X	X
FAP-HA05S-03	10/12/1995	5	Soil	X	X					X	X	X
FAP-HA06S-01	10/12/1995	0.5	Soil	X	X					X	X	X
FAP-HA06S-02	10/12/1995	2.5	Soil	X	X					X	X	X
FAP-HA07S-01*	10/12/1995	0.5	Soil	X	X					X	X	X

## Description of Qualifiers

J	Data are considered quantitatively estimated.
J+	Data are considered quantitatively estimated with a possible high bias.
J-	Data are considered quantitatively estimated with a possible low bias.
N	Data are considered quantitatively presumptive due to tentative analyte identification.
NJ	Data are considered quantitatively presumptive due to tentative analyte identification; the associated value is considered quantitatively estimated.
R	Data are rejected and considered unusable for all purposes.
U	Analyte is considered not present above the level of the associated value.
UJ	Analyte is considered not present above the level of the associated value; the associated value is considered quantitatively estimated.
UJ-	Analyte is considered not present above the level of the associated value; the associated value is considered quantitatively estimated with a possible low bias.



Former Asphalt Plant  
Semivolatile Organic Compounds

Sample ID	Sample Date	Depth	Naphthalene	2-Methylnaphthalene	Acenaphthene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	bis(2-Ethylhexyl)-phthalate	Chrysene	Dibenz(a,h)anthracene	Dibenzofuran
		CRQL	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
		Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
FAP-SS01S-01	10/08/1995	1	<0.105	<0.3	0.15 <sup>J</sup>	2.9 <sup>J</sup>	5.6	3.4	6.5	1.3 <sup>J</sup>	<0.195	4.9	0.36 <sup>J</sup>	<0.165
FAP-SS02S-01	10/08/1995	1	<0.168	<0.48	<0.156	<0.192	0.46 <sup>J</sup>	<0.168	0.65 <sup>J</sup>	<0.252	0.39 <sup>U</sup>	<0.444	<0.288	<0.264
FAP-SS04S-01	10/08/1995	1	0.14 <sup>J</sup>	0.42 <sup>J</sup>	<0.026	0.059 <sup>J</sup>	0.12 <sup>J</sup>	0.087 <sup>J</sup>	0.19 <sup>J</sup>	0.061 <sup>J</sup>	<0.052	0.13 <sup>J</sup>	<0.048	0.076
FAP-HA01S-01	10/12/1995	0.5	0.64 <sup>J</sup>	2 <sup>J</sup>	<0.13	<0.16	<0.2	<0.14	<0.22	<0.21	<0.26	<0.37	<0.24	<0.22
FAP-HA01S-02	10/12/1995	2.5	0.026 <sup>J</sup>	0.088 <sup>J</sup>	<0.013	<0.016	<0.02	<0.014	<0.022	<0.021	<0.026	<0.037	<0.024	<0.022
FAP-HA03S-01	10/12/1995	0.5	2.4 <sup>J</sup>	5.5 <sup>J</sup>	<0.195	<0.24	<0.3	<0.21	<0.33	<0.315	<0.39	<0.555	<0.36	<0.33
FAP-HA05S-01	10/12/1995	0.5	<0.294	<0.84	<0.273	<0.336	<0.42	<0.294	<0.462	<0.441	<0.546	<0.777	<0.504	<0.462
Analyses			17	17	17	17	17	17	17	17	17	17	17	17
Detections			4	4	1	2	3	2	3	2	1	2	1	1
Maximum Concentration			2.4	5.5	0.15	2.9	5.6	3.4	6.5	1.3	0.39	4.9	0.36	0.076
Arizona HBGL - Nonresidential			16450		24500	122500	4.6	0.8	4.6		407	462	0.46	
Arizona HBGL - Nonresidential Hits			0		0	0	1	1	1		0	0	0	

Former Asphalt Plant  
Semivolatile Organic Compounds

Sample ID	Sample Date	Depth	Fluoranthene	Fluorene	Indeno(1,2,3-c,d)pyrene	Phenanthrene	Pyrene
			0.33	0.33	0.33	0.33	0.33
		CRQL Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
FAP-SS01S-01	10/08/1995	1	15	0.44 <sup>J</sup>	1.8 <sup>J</sup>	11	14
FAP-SS02S-01	10/08/1995	1	<0.288	<0.156	<0.372	0.47 <sup>J</sup>	0.78 <sup>J</sup>
FAP-SS04S-01	10/08/1995	1 <sup>J</sup>	0.2 <sup>J</sup>	<0.026	<0.062	0.2 <sup>J</sup>	0.2 <sup>J</sup>
FAP-HA01S-01	10/12/1995	0.5	<0.24	<0.13	<0.31	0.28 <sup>J</sup>	<0.25
FAP-HA01S-02	10/12/1995	2.5	<0.024	<0.013	<0.031	<0.015	<0.025
FAP-HA03S-01	10/12/1995	0.5	<0.36	0.31 <sup>J</sup>	<0.465	0.47 <sup>J</sup>	<0.375
FAP-HA05S-01	10/12/1995	0.5	<0.504	<0.273	<0.651	0.38 <sup>J</sup>	<0.525
Analyses			17	17	17	17	17
Detections			2	2	1	6	3
Maximum Concentration			15	0.44	1.8	11	14
Arizona HBGL - Nonresidential			16450	16450	4.6		12250
Arizona HBGL - Nonresidential Hits			0	0	0		0

## **APPENDIX G**

### SOIL PHYSICAL CHARACTERISTICS

## **APPENDIX H**

### QUANTERRA CERTIFICATES OF ANALYSIS

Note: Certificates of Analysis will be provided in select copies of the Final Report. For access to a complete copy of the Certificates of Analysis, please contact the Camp Navajo Environmental Office at (520) 773-3208.

## **APPENDIX I**

### **MORRISON KNUDSEN, CORP. CLOSURE REPORT FOR REALLOCATED WORK**

Note: Only sections that pertain to the Former Asphalt Plant are included in this Appendix.

## **APPENDIX J**

### SCOPE OF WORK